

Partial English Translation of

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JAPANESE PATENT APPLICATION

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[0080] to [0089]

[0080] Since the semiconductor integrated circuit device fabrication method in the second embodiment of the present invention is the same as that in the first embodiment up to the process of Figure 6, explanations regarding the fabrication steps up to the process of Figure 6 is omitted and steps thereafter will be explained.

[0081] A cobalt film 21 (a fourth metal film) is deposited on the entire surface of the semiconductor substrate 1 where the MOSFETQn is formed and a titanium nitride film 22 (a fifth metal film) is further deposited (Figure 12). The cobalt film 21 forms silicide by reacting with the gate electrode 6 and the n⁺ semiconductor region 8, and the titanium nitride film 22 prevents oxidization or nitriding of cobalt in a thermal treatment to be explained later.

[0082] The cobalt film 21 and the titanium nitride film 22 can be deposited by the publicly known sputtering method. The thicknesses of the cobalt film 21 and the titanium nitride film 22 can be respectively set 10 to 20 nm and 10 nm.

[0083] Next, the semiconductor substrate 1 is subjected to a thermal treatment (a third thermal treatment), to cause a reaction of silicon in the gate electrode 6 and the n⁺-semiconductor region 8 with the cobalt film 21. The cobalt silicide 23 (a first silicide layer) is generated in this way and the non-reacting cobalt film 21 is removed (Figure 13). The third thermal treatment is performed at a temperature of 500 °C for 1 minute. Since this thermal treatment is performed at a relatively low temperature

for a short time period, the cobalt silicide 23 is in a state of cobalt mono-silicide having a high resistivity such as 70 to 80 $\mu \Omega \cdot \text{cm}$. Further, the cobalt silicide 23 can have a thickness of 25 to 40 nm, for example.

[0084] The publicly known wet etching method using aqueous ammonium and the like can be employed for removing the non-reacting cobalt film 21. The nitride layer or the oxide layer formed on the surface of the cobalt silicide 23 can be removed simultaneously with the removal of the cobalt film 21. Based on study of the present inventors, it is clarified that: although the titanium nitride film 22 serves to prevent formation of a nitride film or an oxide film on the surface of the cobalt silicide 23, slight amount of nitride or oxide is formed; if the thus formed nitride layer or the oxide layer is removed, nitrogen or oxygen as an impurity is introduced in the process thereafter, which lowers the resistance of the silicide layer. Therefore, to remove the nitride layer or the oxide layer by wet etching in the present fabrication process is efficient for obtaining the semiconductor integrated circuit device having high performance.

[0085] Next, a titanium nitride film 24 is deposited on the entire surface of the semiconductor substrate 1 (Figure 14). The titanium nitride film 24, which can have a thickness of 10 nm, can be deposited by the publicly known sputtering method.

[0086] Subsequently, the semiconductor substrate 1 is subjected to a thermal treatment (a fourth thermal treatment) at a temperature higher than that in the thermal treatment of the previous process, to change the cobalt silicide 23 made of cobalt mono-silicide into cobalt disilicide. In this way, a low resistance layer 20 is formed. Further, a titanium nitride film 24 is removed (Figure 15).

[0087] The fourth thermal treatment can be performed at a temperature of 700 °C for 1 minute and the low resistance layer 20 generated by this forth thermal treatment has a resistivity of, for example, 15 to 17 $\mu \Omega \cdot \text{cm}$.

Moreover, the low resistance layer 20 can have a film thickness of 30 to 50 nm.

[0088] Since the titanium nitride film 24 is deposited on the cobalt silicide 23, the titanium nitride film 24 serves to prevent oxidization or nitriding of the cobalt silicide 23 in the fourth thermal treatment in the present fabrication process, whereby an oxide layer or a nitride layer is prevented from being formed at the surface of the low resistance layer 20 made of cobalt disilicide. In the thermal treatment at the high temperature of 700 °C, condensations occur in the process that the cobalt silicide 23 made of cobalt mono-silicide is changed into the low resistance layer 20 made of cobalt disilicide. Accordingly, grain boundaries are generated in the low resistance layer 20, thereby increasing the resistance of the low resistance layer 20. However, since the titanium nitride film 24 is deposited on the upper surface of the cobalt silicide 23, physical transfer of grains is inhibited and the condensations are hard to be caused in the aforementioned process. As a result, the resistance of the low resistance layer 20 can set low.

[0089] Finally, a semiconductor integrated circuit device as shown in Figure 11 is almost completed in a manner that the interlayer insulating film 11, the contact hole 12, the wiring 13 and the protection insulating film 14 are formed in the same manner as those in the first embodiment. Hence, explanations regarding formation methods thereof are omitted.